

What is claimed is:

1. A method of processing a substrate by chemical oxide removal (COR) comprising:

determining a desired state for the substrate, wherein the output state comprises at least one target critical dimension (CD);

receiving pre-process metrology data for the substrate, wherein the pre-process metrology data defines an input state for the wafer and comprises pre-process CD data;

determining a process recipe by comparing the input state with the desired state; and

processing the substrate using the process recipe by chemically altering exposed surface layers on the substrate and then thermally treating the chemically altered surface layers.

2. The method of processing a substrate as claimed in claim 1, the method further comprising:

receiving post-process metrology data for the substrate, wherein the post-process metrology data defines an output state and comprises CD data for a processed substrate;

determining if the desired state has been achieved;

determining a new process recipe when the desired state has not been achieved; and

transferring the substrate when the desired state has been achieved.

3. The method of processing a substrate as claimed in claim 1, wherein the pre-process metrology data comprises Optical Digital Profiling (ODP) data.

4. The method of processing a substrate as claimed in claim 1, wherein the post-process metrology data comprises Optical Digital Profiling (ODP) data.

5. The method of processing a substrate as claimed in claim 4, wherein the post-process metrology data comprises SEM data.

6. The method of processing a substrate as claimed in claim 1, wherein the pre-process metrology data comprises at least one to-be-controlled CD and the process recipe is determined by comparing the at least one to-be-controlled CD to the target CD.

7. The method of processing a substrate as claimed in claim 6, wherein the at least one to-be-controlled CD is larger than the target CD and the processing includes performing a trimming process.

8. The method of processing a substrate as claimed in claim 7, wherein the trimming process comprises:

executing a chemical oxide removal (COR) process recipe for a COR module, wherein exposed surfaces on a substrate are chemically treated using the process gas, wherein a solid reaction product is formed on at least one exposed surface; and

executing a post heat treatment (PHT) process recipe for a PHT module by executing comprises evaporating the solid reaction product, thereby trimming the chemically treated exposed surface layers.

9. The method of processing a substrate as claimed in claim 8, further comprising:

repeating the COR process recipe executing and the PHT process recipe executing until the at least one to-be-controlled CD is approximately equal to the target CD.

10. The method of processing a substrate as claimed in 9, further comprising:

receiving post-process metrology data, wherein the post-process metrology data defines an output state and comprises measured CD data for a processed substrate;

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determining if the measured CD is approximately equal to the target CD;  
repeating the COR process recipe executing and the PHT process recipe executing when the measured CD is not approximately equal to the target CD; and  
stopping the execution steps when the measured CD is approximately equal to the target CD.

11. The method of processing a substrate as claimed in claim 7, further comprising determining a trimming amount, wherein the trimming process includes:

executing a chemical oxide removal (COR) process recipe for a COR module, wherein exposed surfaces on a substrate are chemically treated using a process gas, wherein a solid reaction product having a thickness approximately equal to the trimming amount is formed on at least one exposed surface; and

executing a post heat treatment (PHT) process recipe for a PHT module by evaporating the solid reaction product, thereby trimming at least one of the chemically treated exposed surfaces by the trimming amount.

12. The method of processing a substrate as claimed in claim 11, further comprising:

examining a number of pre-qualified control recipes, wherein each control recipe has a pre-determined trim value; and

selecting the control recipe having a pre-determined trim value approximately equal to the difference between the pre-process CD data and the target CD.

13. The method of processing a substrate as claimed in claim 11, further comprising:

creating a binning table, each bin containing a pre-determined trim value;

selecting the bin having a pre-determined trim value approximately equal to the difference between the pre-process CD data and the target CD; and

selecting the pre-qualified control recipe associated with the bin as the process recipe.

14. The method of processing a substrate as claimed in claim 11, further comprising:

creating a lookup table containing a number of recipes; and  
performing a table lookup to determine the process recipe.

15. The method of processing a substrate as claimed in claim 8, wherein the executing a COR process recipe comprises:

transferring the substrate into a module comprising a chemical treatment chamber;

positioning the substrate on a temperature controlled substrate holder mounted within the chemical treatment chamber;

altering the chamber pressure using a vacuum pumping system coupled to the chemical treatment chamber;

providing the process gas using a gas distribution system coupled to the chemical treatment chamber and configured to introduce a process gas into the chemical treatment chamber; and

controlling the COR module, the temperature controlled substrate holder, the vacuum pumping system, and the gas distribution system according to the process recipe.

16. The method of processing a substrate as claimed in claim 8, wherein the executing a PHT process recipe comprises:

transferring the substrate into a module comprising a thermal treatment chamber;

positioning the substrate on a temperature controlled substrate holder mounted within the thermal treatment chamber;

altering the chamber temperature using a temperature controlled upper assembly coupled to the thermal treatment chamber;

altering the chamber pressure using a vacuum pumping system coupled to the thermal treatment chamber; and

controlling the PHT module, the vacuum pumping system, temperature control system, and the temperature controlled substrate holder according to the process recipe.

17. The method of processing a substrate as claimed in claim 8, wherein the exposed surface comprises hard mask material.

18. The method of processing a substrate as claimed in claim 8, wherein the exposed surface comprises oxidized TERA material.

19. The method of processing a substrate as claimed in claim 15, wherein the process gas comprises a fluorine-containing gas and a nitrogen-containing gas.

20. The method of processing a substrate as claimed in claim 19, wherein the process gas comprises HF and  $\text{NH}_3$ .

21. The method of processing a substrate as claimed in claim 8, wherein the process gas comprises a first gas and a second gas that are independently introduced to a processing space.

22. The method of processing a substrate as claimed in claim 15, wherein the temperature of the temperature controlled substrate holder in the chemical treatment chamber ranges from approximately 10° C to approximately 50° C.

23. The method of processing a substrate as claimed in claim 15, wherein the temperature of the substrate mounted on the temperature controlled substrate holder in the chemical treatment chamber ranges from approximately 10° C to approximately 50° C.

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24. The method of processing a substrate as claimed in claim 15, wherein the chemical treatment chamber pressure ranges from approximately 1 mTorr to approximately 100 mTorr.

25. The method of processing a substrate as claimed in claim 15, further comprising controlling the temperature of the process gas in the gas distribution system within a range from approximately 30° to approximately 100° C.

26. The method of processing a substrate as claimed in claim 15, further comprising controlling the temperature of a chemical treatment chamber wall within a range from approximately 30° to approximately 100° C.

27. The method of processing a substrate as claimed in claim 16, wherein the temperature of the temperature controlled substrate holder in the thermal treatment chamber ranges from approximately 10° C to approximately 50° C.

28. The method of processing a substrate as claimed in claim 16, wherein the temperature of the substrate mounted on the temperature controlled substrate holder in the thermal treatment chamber ranges from approximately 10° C to approximately 50° C.

29. The method of processing a substrate as claimed in claim 16, wherein the thermal treatment chamber pressure ranges from approximately 1 mTorr to approximately 100 mTorr.

30. The method of processing a substrate as claimed in claim 16, wherein the temperature of the thermal treatment chamber ranges from approximately 10° C to approximately 50° C.

31. The method of processing a substrate as claimed in claim 16, further comprising:

positioning the substrate at a first distance from the temperature controlled upper assembly during a first time; and  
positioning the substrate at a second distance from the temperature controlled upper assembly during a second time.

32. The method of processing a substrate as claimed in claim 16, further comprising controlling the temperature of a thermal treatment chamber wall within a range from approximately 30° to approximately 100° C

33. The method of processing a substrate as claimed in claim 1, wherein the pre-process metrology data comprises an isolated CD data for at least one isolated feature and nested CD data for at least one nested feature, and the process recipe is determined by comparing the isolated CD data and the nested CD data to the target CD.

34. The method of processing a substrate as claimed in claim 33, further comprising:  
performing a first trimming process based on the difference between the isolated CD data and the target CD data; and  
performing a second trimming process based on the difference between the nested CD data and the target CD data.

35. The method of processing a substrate as claimed in claim 33, further comprising:  
determining a first delta based on the difference between CD data for a first feature and the target CD data;  
determining a second delta based on the difference between CD data for a second feature and the target CD data; and  
performing a trimming process based on the difference between the first delta and the second delta.

36. The method of processing a substrate as claimed in claim 33, wherein the pre-process metrology data includes goodness-of-fit (GOF) data, and depth data.

37. The method of processing a substrate as claimed in claim 1, further comprising:

receiving post-process metrology data for the substrate, wherein the post-process metrology data defines an output state and comprises CD data for a processed substrate;

computing a predicted state for the wafer based on the process characteristics and a process model;

determining if the predicted state has been achieved by comparing the output state with the predicted state; and

computing a process model offset when the predicted state has not been achieved.

38. The method of processing a substrate as claimed in claim 1, wherein the process recipe is determined by executing a control strategy and a control plan.

39. The method of processing a substrate as claimed in claim 8, further comprising:

transferring the substrate from the COR module to the PHT module.

40. A processing system for treating a substrate comprising:

a processing subsystem comprising a chemical oxidation removal (COR) module for chemically altering exposed surface layers on the substrate, a post heat treatment (PHT) module for thermally treating the chemically altered surface layers on the substrate, and an isolation assembly coupled between the PHT module and the COR module;

a first integrated metrology module (IMM) coupled to the processing subsystem for providing pre-process metrology data that determines an input state for the substrate; and



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a control device coupled to the processing subsystem and the first IMM, wherein the control device determines a process recipe for changing the wafer from the input state to the desired state; and executes the process recipe.

41. The processing system for treating a substrate as claimed in claim 40, wherein the COR module further comprises a temperature controlled chemical treatment chamber, a temperature controlled substrate holder mounted within the chemical treatment chamber and configured to be substantially thermally insulated from the chemical treatment chamber, a vacuum pumping system coupled to the chemical treatment chamber, and a temperature controlled gas distribution system for introducing one or more process gases into the chemical treatment chamber.

42. The processing system for treating a substrate as claimed in claim 40, wherein the PHT module further comprises a temperature controlled thermal treatment chamber, a temperature controlled substrate holder mounted within the thermal treatment chamber and configured to be substantially thermally insulated from the thermal treatment chamber, and a vacuum pumping system coupled to the thermal treatment chamber.

43. The processing system for treating a substrate as claimed in claim 40, wherein the control means further comprises means for controlling at least one of a chemical treatment chamber temperature, a chemical treatment gas distribution system temperature, a chemical treatment substrate holder temperature, a chemical treatment substrate temperature, a chemical treatment processing pressure, a chemical treatment gas flow rate, a thermal treatment chamber temperature, a thermal treatment substrate holder temperature, a thermal treatment substrate temperature, and a thermal treatment processing pressure.

44. The processing system for treating a substrate as claimed in claim 40, wherein the isolation assembly comprises at least one of a thermal insulation assembly, a gate valve assembly, and a transfer system.

45. The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled chemical treatment chamber comprises a wall heating element.

46. The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled gas distribution system comprises at least one gas distribution plate, the gas distribution plate comprising one or more gas injection orifices.

47. The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled substrate holder in the chemical treatment chamber comprises at least one of an electrostatic clamping system, a back-side gas supply system, and one or more temperature control elements.

48. The processing system for treating a substrate as claimed in claim 41, wherein the temperature controlled substrate holder in the chemical treatment chamber includes one or more temperature control elements.

49. The processing system for treating a substrate as claimed in claim 41, wherein the gas distribution system comprises a first gas distribution plenum and a first gas distribution plate having a first array of one or more orifices and a second array of one or more orifices for coupling the first gas to the process space through the first array of one or more orifices in the first gas distribution plate, and a second gas distribution plenum and a second gas distribution plate having passages therein for coupling the second gas to the process space through the passages in the second gas distribution plate and the second array of one or more orifices in the first gas distribution plate.

50. The processing system for treating a substrate as claimed in claim 49, wherein the first gas and the second gas are independently introduced to the process space.

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51. The processing system for treating a substrate as claimed in claim 42, wherein the PHT module further comprises a substrate lifter assembly coupled to the thermal treatment chamber for vertically translating the substrate between a transfer plane and the substrate holder.

52. The processing system as recited in claim 40, wherein the processing subsystem is coupled to a manufacturing system.

53. The processing system as recited in claim 40, wherein the control means also determines if the desired state has been achieved.